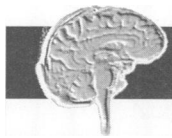

Neurorehabilitation

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Neurorehabilitation is a relatively recent concept and did not become an issue until after World War II. Many of the casualties of that war who suffered spinal cord and head injury avoided death from infection by receiving antibiotics, and the survivors needed help to regain some degree of independence. Antibiotics also made it possible for persons who had suffered serious stroke to survive infectious complications such as pneumonia and urinary tract infection. This has left a large number of persons living with serious physical disability.

Physical disability caused by neurologic disease is the most common reason for admitting patients to a rehabilitation hospital. The conditions that are most frequently encountered on a neurorehabilitation service are stroke, traumatic head injury, spinal cord injury, multiple sclerosis, Parkinson's disease, and devastating peripheral neuropathies such as the Guillain-Barré syndrome. Patients with these conditions usually account for about two thirds of the patients in any modern rehabilitation hospital. These problems are neurologic, but in the past they have been managed largely by physiatrists. The scope of the problem of neurologic disability has enlarged with the development of physical medicine and rehabilitation programs that were heavily focused on patients with spinal cord injury.

Neurorehabilitation has become more complicated, and the level of intensity of care provided has increased, so it is important that neurologists assume more responsibility for the long-term management of these patients. Care for patients who need inpatient rehabilitation from physical disability caused by a neurologic illness requires a team of professionals with special skills including physical, occupational, and speech therapists, rehabilitation nurses, social workers, guidance counselors, and peer counselors. Managing all of these activities becomes the responsibility of the physician in charge.

There is no evidence that programs of rehabilitation have any effect on restoring impaired nervous system function or enhancing natural recovery following disease or injury. These programs do improve patients' ability to perform daily activities and self-care and to achieve functional independence. The scope of the problems of neurorehabilitation is best presented by a brief review of the usual conditions that are thought suitable for treatment.

Cerebrovascular Disease

Stroke is the most common cause of physical disability in persons older than 60 years, and 40% of all stroke survivors require inpatient rehabilitation care. In the United States, 500,000 to 600,000 new strokes occur every year. With the current mortality rate running about 20% to 25%, this leaves a large group of persons with physical disability.

Stroke is the most common reason for the admission of adults to neurorehabilitation services. The cause of the stroke does not dictate treatment; the focus of treatment is on the functional deficit, most commonly hemiparesis or hemiplegia. The number of patients who are suitable for stroke rehabilitation is not large. In an analysis of this problem at the Burke Rehabilitation Hospital of Cornell University Medical College (White Plains, NY), only about a third of patients with stroke were suitable for inpatient rehabilitative care. About 20% of persons with stroke will die, and 10% will recover so completely that they have no need for rehabilitative services. This leaves approximately 70% who have substantial physical disability that requires rehabilitation. Of this 70%, about 10% will be so functional that they can be managed adequately as outpatients. Half of the remainder will be so devastated by the severity of the stroke or have such a decline in intellectual capacity or comorbidity from heart disease that they are unable to engage in rehabilitation programs. This leaves approximately a third of the victims of stroke as suitable candidates for admission for acute rehabilitation. Similar data have been reported from England, where it was found that only about 12% to 15% of patients with stroke were suitable candidates for inpatient rehabilitation.

Programs of inpatient rehabilitation are designed to teach patients how to manage with their remaining intact function and become as independent as possible. Such programs depend on the ability of the stroke survivor to learn. In the most uncomplicated situation, this means that if someone has a left cerebral infarct and a right hemiplegia, the patient must learn how to be left-handed. Other problems for patients in inpatient rehabilitation services include the frequent comorbidity from other organ systems affected by generalized atherosclerotic vascular disease in the heart and peripheral vessels. These conditions often are as serious or more so than stroke.

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Most commonly a person who enters a rehabilitation program after having a stroke has some degree of hemiparesis. The arm and hand are almost always more severely affected than the leg. Generally there is some return of function in the lower extremities, more often proximally than distally.[1] This makes it possible for suitable orthotic devices to help patients walk.

The chances of successfully rehabilitating a person with stroke vary widely, and goals must be based on the degree of neurologic impairment. In studies by Reding and Potes, persons with only motor involvement had the best outcome, when judged by the ability to walk 46 m (150 ft) without assistance or to attain self-care as measured by the Barthel Index.[2] For patients who also had a sensory deficit, the chances of reaching these goals declined (Figure 1). If the patient had motor involvement, sensory involvement, and hemianopsia, the chance of attaining these goals was limited. Reducing the goals to walking with assistance and achieving a marginal ability for self-care, those patients with only motor involvement had the best chance for improvement, but those with motor, sensory, and visual involvement often could achieve these goals if they were kept in rehabilitation programs long enough (Figure 2). Improvement following stroke occurs in the first three months (Figure 3).[3,4] Further improvement may occur after three months, but it is generally less notable.

Questions are often raised about whether dedicated stroke rehabilitation units are desirable.[5,6] The evidence is fairly good that staff who are expert in dealing with patients who have had strokes can anticipate patients' problems and prevent them from becoming serious. Dedicated stroke units also provide a cadre of patients who set an example for newly admitted patients about what can be accomplished with stroke rehabilitation. In most inpatient stroke rehabilitation programs, about 95% of the patients are able to return home, usually with minimal assistance from care givers. In follow-up studies, the improvement has been sustained.

Head Injury

The number of patients requiring rehabilitation after head injury is difficult to determine because head injury

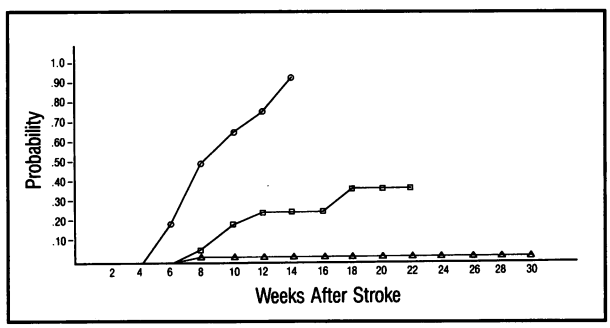

Figure 1.—The time course and probability of walking 46 m (150 ft) or more without assistance are shown for patients with motor deficit only (○), those with motor and sensory deficits (□), and those with sensory and visual deficits (△) following stroke (from Reding and Potes[2]).

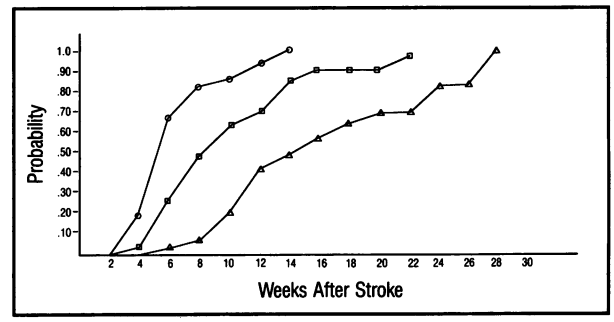

Figure 2.—The time course and probability of walking 46 m (150 ft) or more with assistance are shown for patients with motor deficit only (○), those with motor and sensory deficits (□), and those with sensory and visual deficits (△) following stroke (from Reding and Potes[2]).

is not always coded in medical records according to the degree of severity. The incidence of head injury is thought to be about 200 per 100,000 population, with a death rate of 10% to 20% and a prevalence of 400 per 100,000.[7] About 10% to 20% of persons who have a diagnosis of head injury made in an emergency department are estimated to have brain damage serious enough to require some form of rehabilitation. This group of patients is of considerable importance because head injury is most likely to occur in younger persons. Those who survive a head injury often will require lifelong public assistance and physical help to manage disability and intellectual impairment. This puts an enormous burden on families and social organizations.

Head injury almost always causes not only physical disability and intellectual disability but also personality change. It is often accompanied by many serious orthopedic problems. In young persons neurologic and cognitive improvement is likely, but striking improvement is uncommon in older victims. Intellectual impairment and personality change are the most difficult problems to manage in head injury rehabilitation.[8-10] Patients in coma following injury need ongoing rehabilitative care, especially passive range-of-motion exercises to avoid contracture. Coma stimulation programs have been tried without good evidence of effectiveness, and their specificity is almost impossible to determine because of the background noise coming from the almost constant nonspecific stimulation that occurs in patients in a hospital. The management of patients with motor deficits is similar to that of patients with stroke and consists of strengthening remaining function and providing education in using intact function to improve patients' ability to perform their daily activities.

Programs that deal with cognitive impairment are directed toward behavior modification, relearning social skills, and adapting patients to reduced intellectual levels. Specific cognitive rehabilitation techniques directed at memory and behavior improvement are in use. They have shown some effect on specific problems such as memory loss, but this improvement is not always applicable to other aspects of cognition and behavior.[11] Patients with serious behavior problems often need hospital stays with

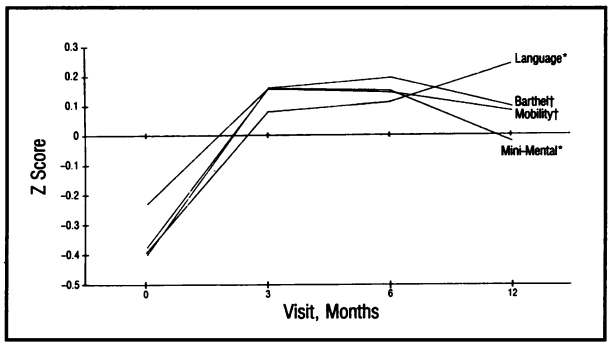

Figure 3.—The time course of improvement in functional deficits of patients following stroke is shown. Four tests were used to measure the amount of improvement from the acute period to 3 months (from Kelly-Hayes et al[3]). * = $P < .01$, † = $P < .05$

restriction of independence to avoid their harming themselves and others. Using medication to reduce hostile and impulsive behavior should be avoided because the usual agents tend to impair orientation and behavior. Reentry programs that teach head injury patients social skills and appropriate behavior for daily living are often necessary for those with cognitive impairment. Some patients become such difficult management problems that they cannot live at home. Improved emergency care for head injury victims is increasing the number of survivors and the need for extensive neurorehabilitation programs and long-term care. This is in part balanced by a decline in the incidence of severe head injury, due to the use of seat belts and airbags in automobiles.

Spinal Cord Injury

Spinal cord injury is a serious problem because of the degree of disability it can cause. It occurs predominantly in two age groups: patients older than 50 years who have cervical osteoarthritis and spondylosis; and young men aged 15 to 25, following automobile or sporting accidents or violence. Survivors, especially those with cervical spinal cord injury, are usually seriously disabled and need expensive and continuous support. The rehabilitation of patients with spinal cord injury is dictated by the physiologic deficits that occur following spinal cord damage or transection.[12-15]

For persons with paraplegia, the problems are compounded by a loss of control over bowel and bladder function and a loss of sensory perception below the lesion level. Rehabilitation programs for those with paraplegia are designed to condition the responses that trigger bladder voiding reflexes by external abdominal pressure or other means, so that patients can predictably empty their bladders. Conditioning bowel function by suppositories and a regular pattern of bowel activity usually assures that the person is not incontinent. Patients are taught to protect areas of anesthetic skin to avoid the difficult problem of decubitus ulcers. Spasticity initially may be a problem for patients with paraplegia and is managed by physical therapy and medication. Later, spasticity usually becomes less of a problem. Programs to increase strength in the upper extremities are necessary for patients to be able to transfer from wheelchairs to automobiles and to move easily and efficiently in wheelchairs. Although patients with paraplegia can be braced so that they can walk and take some steps, they usually find that mobility in a wheelchair is more efficient than trying to manage with braces and canes.

For quadriplegic patients with cervical spinal cord damage, problems are much more complex and difficult. Patients are disconnected from supersegmental control of a number of important functions, such as autonomic nervous system controls and body heat loss and conservation, and are seriously disabled by a substantial loss of voluntary motor function. The lower the cervical spinal cord injury, the more functional the patient can become. Patients who are injured at C5-6 or C6-7 generally have remaining upper arm function that can be enhanced by exercises. High cervical lesions usually leave a patient totally dependent on others. Patients also need training and conditioning in bladder and bowel function so that bladder and bowel emptying can be predictably carried out without the risk of incontinence and so that bladder emptying can be adequate to prevent urinary tract infection. Avoiding excessive high and low environmental temperatures is important because the body has lost its connection with the brain mechanism that senses body temperature changes so that sweating and shivering do not occur below the level of the lesion. Such patients often find it extremely uncomfortable to be outside in warm weather and find it extremely difficult to lose the sensation of being cold when exposed to cold weather.

Perhaps the most difficult problem in persons with cervical spinal cord injury is hyperactivity of the autonomic nervous system. Noxious stimulation below the level of the spinal cord lesion is likely to set off excessive autonomic activity, with elevations of blood pressure, sweating of the head, headache, and a reduced heart rate. This can become dangerous because the blood pressure can rise so high that intracerebral hemorrhage may occur. The most common causes of this abnormal reflex response are a distended bladder or rectum or unrecognized sources of noxious stimulation such as infected toenails or bedsores. Prompt attention to these sources of noxious stimulation usually deals with the problem adequately, although pharmacologic means of lowering the blood pressure may be necessary. Orthostatic hypotension is common in patients with cervical spinal cord injury. Its presence complicates and delays the assumption of the sitting position. Patients usually adapt gradually with sustained acceptable blood pressure while sitting.

The psychological effects of spinal cord injury, especially in the young, revolve around the loss of the capacity to be active, although many patients with paraplegia and quadriplegia do surprisingly well with the aid of modern electronic technology in dealing with their environment and being able to be employed. Sexual dysfunction is a considerable problem, and counseling on this issue is needed as patients begin to realize that the impairments they have after injury may be permanent.

Spinal cord damage also occurs in older persons with

hypertrophic osteoarthritis in the cervical and thoracic spine. They may injure their spinal cord by falling or by gradual pressure on the spinal cord. Surgical management with enlargement of the space available for the spinal cord and nerve roots can be effective in dealing with the problem. Rehabilitation programs are based on the amount of impaired function and are similar to those for younger victims.

Multiple Sclerosis

Neurorehabilitation for persons with multiple sclerosis is becoming increasingly important because of evidence that improvement can occur with carefully monitored exercise and physical therapy. It has also become evident that a neurorehabilitation service is the most suitable place for hospitalization when patients become ill with the common complications associated with multiple sclerosis, such as spasticity, urinary tract infections, decubiti, and exacerbated disease.[16] Patients with multiple sclerosis then do not have the complications of decreased physical activity while they are in an acute care hospital and decreased mobility at discharge. In acute care hospitals, patients are rarely adequately mobilized during hospital stays and often have prolonged periods of bed rest or inactivity.

The common reason for admission of patients with multiple sclerosis to rehabilitation facilities is evidence of spinal cord damage producing partial or complete paraplegia and sometimes quadriplegia. Programs for these patients are similar to those for patients with traumatic spinal cord injury. Disease progression makes rehabilitation results difficult to evaluate, but keeping patients with multiple sclerosis physically active and improving remaining strength allow many patients to remain independent in self-care and often in employment. Inpatient rehabilitation programs for patients with multiple sclerosis are often extremely effective in improving function, but it is difficult to guarantee that improvement produced by a rehabilitation program will be sustained.

Parkinson's Disease

Rehabilitation programs for patients with Parkinson's disease are again becoming more important after being nearly abandoned with the advent of levodopa and dopamine agonist treatment. Before these agents were available, virtually all patients with Parkinson's disease were involved in rehabilitation and exercise programs. It is now evident that this kind of care should be an integral part of the management of these patients.

Patients with Parkinson's disease often benefit from brief periods of inpatient rehabilitation.[17,18] The tendency for a person with Parkinson's disease is generally to become less physically active and to spend large amounts of time sitting. It then becomes difficult to determine reasons for excessive fatigue or an inability to perform self-care activities, and the question arises as to whether this is because of the progression of the disease or to general deconditioning. Placing inpatients on programs of fairly vigorous regular exercise has improved function in many. The distance patients can walk increases, and their need for assistance in daily activities is reduced. These results occur without notable changes in medication. The effects of rehabilitation programs tend to last only six to nine months. The reason for this is not disease progression, but, rather, that when patients return to their home environment, they lapse into their previous habits of inactivity.

Patients with extensive peripheral neuropathy, such as that which occurs following the Guillain-Barré syndrome, are frequently admitted to rehabilitation hospitals because of serious disability. Recovery over several months is common for these patients, and during their period of recovery, it is extremely important to improve their tolerance for physical activity and to avoid the complications that are related to immobility, such as pressure sores, thrombophlebitis, and pulmonary embolus. These persons often benefit from careful orthotic evaluation and the construction of braces to take care of foot and wrist drop while they are recovering. Pain is often a problem, with hyperalgesia and hyperesthesia in parts where peripheral nerve regrowth is taking place; it generally can be managed with analgesics and antidepressants.

The Future of Neurorehabilitation

A number of attempts have been made to apply the data from experiments with animals that suggest that recovery can be augmented and speeded by pharmacologic means and that certain commonly used medications can impede the recovery process. Amphetamine and yohimbine have been found to enhance recovery in rats and cats that have an experimental lesion that produces hemiparesis.[19,20] Agents that retard recovery include phenytoin, haloperidol, clonidine, diazepam, and prazosin.[21,22] Studies in patients with stroke on the effect of amphetamine on recovery and enhancement of the rehabilitation process have not produced convincing evidence of benefit. The potential of using pharmacologic enhancement of recovery is now being extensively investigated as is the potential of clinically used agents to retard recovery.

Promise of a cure of the conditions that bring patients to rehabilitation hospitals is suggested by current laboratory research, but the prospect for the immediate future is limited. In the interval, professionals who have a special interest in the function of the central nervous system should apply their thinking and the scientific method to the evaluation of the problem of rehabilitation to find out what is best to do and how best to do it.

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